ON CERTAIN SHOOT-BEARING TUMOURS OF EUCALYPTS AND ANGOPHORAS, AND THEIR MODIFYING INFLUENCE ON THE GROWTH-HABIT OF THE PLANTS.

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(Plates iv.-xxvi.)

The Eucalypts, representing about 230 recognised species, contribute one of the dominant, phanerogamic elements to the Australian flora. They are an assemblage of plants remarkable in many ways, widely distributed over an entire continent, extending also to the circumjacent islands; and now acclimatised to some extent in other countries. One of the astonishing things about them is the liability of the seedlings of so many species to shoot-bearing galls or tumours of an uncommon type.

Their specially distinctive characters result from a fortuitous combination of some simple, natural, and favouring conditions present in quite young seedlings. Firstly, they originate in the axils of the cotyledons only, or, in addition, in a few pairs of leaf-axils successively above these, where the buds are, as paired but at first independent, proliferating outgrowths of cambium-tissue; and, as a rule, the outgrowths, or the axillary stem-nodules, as we may call them at this stage, succeed in taking possession of the dormant buds, and incorporating them in the stem-nodules. This is how the latter, as well as the composite tumours to which they may give rise, come to have buds or shoots.

Secondly, the young seedlings usually have opposite and distichous leaves; and, correspondingly, the stem-nodules are also opposite and distichous; but as, under favourable conditions, the latter grow faster than the stem thickens, the paired nodules meet and fuse, and the fusions then encircle the stem.

Thirdly, as a rule, the first and second internodes do not length too much or too soon to permit of the concrescence of the fused pairs, giving rise to composite, shoot-bearing, stem-encircling tumours. The third and succeeding internodes are more variable, but often permit of the addition of a fourth and a fifth pair of fused nodules to the concrescence of the first three pairs. More than five pairs, if developed, are apt to be left isolated, and are only of minor or of no importance. Three to five pairs are the really effective and important ones.

Fourthly, the hypocotyl is not too long, so that, as the composite, stem-encircling tumour increases in size, and grows downwards, it is able to tamper with as much of the root-system as it encounters, encircling and fusing with the upper portion of the tap-root, and the proximal portions of any lateral roots that come in its way, intercepting more or less of the water they may contain, at the expense of the seedling-stem, and to the advantage of the tumour and its inhabitants. In this stage, they are composite, stem-encircling, shoot-bearing, root-incorporating [but not root-emitting] tumours.

The stem-nodules of seedlings of refractory species, or of refractory individuals of any species, may not get beyond the first stage. In such cases, the proliferation slows down, and the axillary stem-nodules come to a standstill. A mild attack has run its course without accomplishing anything of importance, or interfering with the growth-habit of the seedlings.

Seedlings of susceptible species, from accidental or other causes, may not get beyond the second stage, through the composite, encircling tumours failing to incorporate roots. In such cases, the composite tumours may last for some time, but not as long as those which can complete the third stage.

In the Non-Mallee Eucalypts, the last stage may last for some years, until the plants are getting ready to enter on the young sapling stage, but not indefinitely. In the Mallees, however, it may persist throughout life, and the tumours may attain an enormous size. But the distinction between the two groups of Eucalypts does not correspond to inherent differences in their tumours, as such; but to differences in the kind of roots incorporated in the two cases. In other words, the Non-Mallees have ordinary roots; the Mallees have water-storing roots.

In all three stages, the buds may remain dormant, or they may develop shoots, according to circumstances. In the first case, an appropriate stimulus will readily cause shoots to develop. Anomalies, eccentricities, and examples of erratic behaviour are common, and very instructive.

In addition to the axillary stem-nodules, unpaired, not definitely localised nodules sometimes develop at a lower level than the cotyledons, either on the hypocotyl or on the taproot, of some seedlings. These are very suggestive of wound-infection, and are sometimes obviously pathological. This is particularly the case in most seedlings of two of the Bloodwoods, in which very extensive root-invasion may take place.

In all these cases, we can find no escape from the conclusion, that the exciting cause of the nodules is attributable to parasitic soil-organisms, probably of the same species, finding vulnerable points for attack under slightly different conditions; and causing the cambium-tissue to proliferate and grow outwards. The nodules are not caused by insects, or other visible parasites. They are outgrowths of proliferating tissue, and not natural growths. They may be a nuisance to the plants, and may temporarily or permanently interfere with the natural growth-habit. Moreover, if possible, when opportunity offers, they are brought to a standstill.

The root-nodules of four young seedlings, of which three are figured. in every case have incorporated the basal portion of a young root. They suggest analogy to what Beyerinck has observed in studying the root-nodules of Leguminosæ—"The splitting of the primary bark for the emission of the side-roots is the special means of entrance of *B. radicicola*" [Erwin Smith, "Bacterial Diseases," ii., p.103].

The vulnerability of the axils may be due to a weak spot which arises in connection with the differentiation of the buds, or which is exposed about the base of the petioles when the young leaves expand. Until serial, transverse, and superficial, longitudinal sections through the axillary region of series of seedlings have been studied, it is useless to speculate further.

In the belief that soil-organisms are responsible for the problem we are interested in, we began a search for records of similar or analogous cases.

Dr. F. Erwin Smith, in the second volume of his important treatise on "Bacteria in relation to Plant-Diseases" (1911), discusses, in detail, wound-infections (p.51), and also infections through natural openings, grouped as nectarial, waterpore-, stomatal, and lenticellate infections. But we failed to find any reference to axillary infections. As we came to know later, axillary infections had not then come under the author's notice.

It was with great interest that we unexpectedly met with a paper by Mr Clayton O. Smith, of California, in which he not only mentions the possibility of axillary infection in the axils of the cotyledons, in stone-fruits, but he gives particulars about the axillary nodules of some Eucalypt seedlings which came under his notice. We quote all that the author has to say about these, and about cognate matters, for three reasons. The paper is not contained in the Society's library, and we know of only one copy of it in Sydney. It contains the first satisfactory record known to us of the realisation of the fact, that the stem-nodules are axillary; as well as the only records, that we know of, of the successful inoculation of Australian plants, including Eucalypts, from cultures of soil-organisms. It is also of interest to note what an experienced plant-pathologist thought of the stem-nodules. Mr. Clayton Smith does not mention the fusion of the axillary knots, or that they had shoots, or that they incorporated roots. *E. tereticornis* is the only species mentioned, and seedlings of this species are sometimes more or less refractory. It may be, therefore, that with only limited material available, and without Australian experience of Eucalypts to guide him, he may have unknowingly experimented with seedlings that were not as satisfactory for the purpose as others might have been.

"Further Proof of the Cause and Infectiousness of Crown Gall." By Clayton O. Smith. Univ. Cal. Publications, College of Agric., Agric. Experim. Station Bulletin No.235 (Dec. 1912).

"Bacterial Nature of [the] Disease" (p.534).—There is now abundant proof, that these knots [Crown-Gall on the 30 Hosts enumerated] are caused by a bacterial organism that enters the tissue through some injury, or possibly at the point where the cotyledons of such seeds as those of the stone-fruits are attached to the young plant. In Eucalyptus seedlings, the natural knots often appear opposite each other where the cotyledons have previously been attached, also the quince knots appear first at the node about the old leaf-scar. All the evidence we have, goes to show that some injury or weakness is necessary for infection to take place."

[Legend of Text-fig.21, p.549].—"Artificially caused galls on forest red gum [*Eucalyptus tereticornis*]. Crown Gall has not been known to attack the various species of Eucalyptus in nature. The significance of swellings found frequently at the crown of young gum trees is not yet understood. They do not appear to be detrimental to the tree."

Victoria Bottle Tree (*Sterculia diversifolia*) [fig.20], and Flame Tree (*S. acerifolia*) were successfully inoculated (p.552).

"Forest Red Gum (*E. tereticornis*) [fig.21].—Seedlings of from four to six feet were inoculated. The first successful inoculations were made May 16, 1910. On March 25, 1912, there was one large knot and one very small one at points of inoculation. September 2, 1911, inoculated a seedling about one half inch in diameter. February 20, 1912, there were two small knots. On March 26, 1912, one of these knots had grown rapidly in size, the other had not changed."

"Inoculations were made on small seedlings, July 20, 1910, on the branches. Typical roundish knots or galls had developed on September 5, 1910."

[Silky] Oak (*Grevillea robusta*) (p.552), gave negative results. "This is probably due to the slow growth of the tree."

Under the heading of *Other Galls that are at present little understood* (p.552).—"*Eucalyptus Knot* (pp.553-554)—Galls occur frequently on the small seedlings. These are hard knots that occur always at the nodes. There will often be a gall on each side of the plant where cotyledons or the opposite leaves have previously been. We have had small seedlings with these natural galls under observation for about three years. In some cases there is an increase in size in the knots, which still continue to be hard, and do not in any way appear to weaken the trees. In many cases, the diseased trees have completely outgrown the disease, and in these instances there has been but little increase in size of [the] original knots. From our observations, the disease does not seem to seriously injure the growth of the tree. Numerous attempts to isolate a pathogenic organism have resulted in failure, although we still believe the galls may be caused by such an organism."

Quite recently three papers by Dr. Erwin F. Smith, of the U.S. Department of Agriculture, have come to hand, which have a very important bearing on the problem of the shoot-bearing tumours of Eucalypts.* These also are to be found only in a few libraries. They are important because they relate to the first records of natural, axillary, shoot-bearing tumours caused by soil-organisms; and axillary and other special tumours produced by artificial inoculations. We give the following extracts from these:—

Dr. Erwin Smith says in his paper published in August, 1916: "Last winter, I discovered that when growing plants are inoculated in the vicinity of dormant buds, a new type of tumor is produced. This tumor bears, on its surface, diminutive abortive shoots (vegetative or floral) and in its interior, along with the cancer-cells, numerous fragments of embryonic tissues, variously fused and oriented, often upside down and curiously jumbled These tumors have never been seen by the writer in nature, or at least if seen, not recognised as crown-gall tumors, but undoubtedly we shall now find them." [Then follows reference to a footnote "As this goes to press, I have had confirmation of this belief, having received from a florist in Massachusetts, a crown-gall of the rose showing abortive shoots growing out of stem-tumor."] Dr. Smith continues—"These tumors have all

* "Further Evidence as to the Relation between Crown-Gall and Cancer," Proc. Nat. Acad. Sci. U. S. A., ii., p.444 (August, 1916). "Mecanism of Overgrowth in Plants," Proc. Amer. Phil. Soc. Philadelphia. lvi., No.6, p.439 (August, 1917). "Embryomas in Plants (produced by Bacterial Inoculations)," Bulletin Johns Hopkins Hospital, xxviii., No. 319, p.279 (September, 1917).

been produced with *Bacterium tumefaciens*. . . . . . . The plants chiefly experimented on have been Pelargonium, Nicotiana, Lycopersicum, Citrus, and Ricinus. All of these and some others (Mangifera, Allamanda, etc.) have yielded teratoid tumors from inoculations in leaf-axils."

In a later paper, Dr. Erwin Smith refers again to the accidental circumstance which suggested to him the desirability of inoculating plants in leaf-axils and growing-points, in addition to internodes, as he had been doing for years. "We had found indeed, as early as 1908-9, and had produced by bacterial inoculation, plant-tumors bearing roots, but the full meaning of this discovery, as related to cancer, did not occur to me until early in 1916, when I found crown-gall tumors bearing leafy shoots on some of our inoculated hothouse geraniums. Beginning with this discovery, I made numerous inoculations in the leaf-axils of various plants, which resulted in the production of leafy tumors, and subsequently I produced them on leaves and on cut internodes where no buds occur normally. Tumors bearing roots have also been produced by us on the top of plants, and in one cut internode of Tobacco I succeeded in producing a tumor which bore flower-buds. These perishable root-bearing and shoot-bearing tumors I regard as plant-embryomas, and have so described them [Journ. Cancer Research, April, 1916, p.241]."

We have not had access to the paper last mentioned. But in the Johns Hopkins Bulletin for September, 1917, Dr. Erwin Smith has given further particulars, and numerous illustrations of the embryomas resulting from his inoculations, together with two (fig.63) of "Pelargonium teratoid tumors originating naturally . . . on gardener's cuttings bedded in earth for propagation. The specimens came from a gardener's house near Baltimore."

We give the following brief extract from this paper—"In April 1916, I announced the discovery of a new type of crown-gall, *i.e.*, one containing numerous leafy shoots, and showed that I could produce it at will by making my bacterial inoculations in leaf-axils where there is a dormant bud. . . . . . I have since discovered that leafy crown-galls occur in nature on various plants, *e.g*, on the rose, and on the carnation."

If the shoot-bearing, axillary nodules of Australian Eucalypts are caused by parasitic soil-organisms, under natural conditions, then they seem to be comparable with the five cases of "leafy tumours" [on Geranium, Pelargonium (two), Rose, and Carnation] due to axillary infection by the organism causing Crown-Gall under natural conditions cited, by Dr. Erwin Smith.

Were it not that, by a fortuitous combination of circumstances, the axillary stem-nodules are able to fuse in pairs, the fused pairs to concresce, and the re-inforced, composite, stem-encircling tumours thus enabled to incorporate roots and so last for some considerable time or even permanently, both the nodules, and any shoots they might develop, would be short-lived and abortive; as they actually are in refractory seedlings; and as the shoots on the lower pairs of concrescences also are.

They are not exactly comparable with the embryomas produced by Dr. Erwin Smith's inoculations in leaf-axils and growing-points. But the circumstances and conditions in the two cases are not parallel. Erwin Smith's experiments were mostly, but not entirely, carried out with soft-tissued plants, which responded promptly; the organisms were introduced by needle inoculations right into the tissues of the plants, causing profound disturbances; and the inoculations were made in upper axils.

But in the natural inoculations in the lower axils of the young seedlings of Eucalypts, which furnish some of the most valued hardwood timbers, we are inclined to think that the organisms are confined to the outgrowths, and the encircling tumours to which they give rise, and probably do not invade the tissues of the seedlings. The tumours do not kill the seedlings, or even seriously damage their tissues. They are a drag on the normal development of the plants, especially so when shoots do not develop, and by interfering with the water-supply, and also by their shoots preventing the development of the normal branching. In the Mallees, so much water is intercepted by the tumours, that the seedling-stem is dwarfed; and, by the persistence of the shoots, the growth-habit is permanently distorted, so that the plants are prevented from realising their potentialities as trees. The seedling-stem may possibly be sometimes crowded out and got rid of.

But the stem-nodules, as well as the composite tumours to which they give rise, are complex tumours, composed of both somatic cells and germ-cells; and the latter are totipotent, because in the persistent composite tumours of the Mallees, the tumour-shoots complete their growth, flower and fruit, and produce seed. Even in the Non-Mallees, if the seedling-stem is lost, two tumour-shoots may take its place, attain to tree-size, and flower and fruit. But they do not prematurely disclose their embryonic possibilities, in the way that some of Erwin Smith's artificially produced monstrosities did. Also the production of these tumours in Eucalypts under natural conditions is a matter of long standing. The Mallee Scrubs, which must have been the developments of centuries, were in their prime, when civilised man first saw them, nearly 101 years ago.

We may next briefly review the Australian contributions to a solution of the problem we are interested in. These relate chiefly to the Mallees. The earliest descriptions of the make-up of these curious plants, by Allan Cunningham,* Tenison-Woods,† and Baron von Mueller,‡ are subject to the drawback that, when these botanists visited the untouched Mallee-Scrubs, there was no opportunity of seeing uprooted plants. Two of the Baron's definitions will suffice. Under *E. oleosa* (Dec. vii.): "Shrubby or somewhat arborescent. . . . . . . It is this species which forms a large ingredient of the 'Mallee-Scrub,' constituting tall bushes branched from the root." Under *E. stricta* (Dec. x.): "Shrubby or somewhat arborescent . . . . .; habit that of the Mallee-Eucalypts, with many stems from one root."

Mr. J. Ednie Brown,§ in 1882, gave his interpretation of the "root" of the Mallees, from which the stems are said to rise, as "being apparently a kind of dwarf trunk, the stems of our description [under *E. gracilis.* "A Mallee tree with several stems"] representing its branches."

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* Oxley's Journal (in the entry for June 10, 1817), p.63 (1820).

† "Geological Observations in South Australia," p.33 (1862). Also, Proc. Linn. Soc. N. S. Wales, vii., p.566 (1883).

‡ "Eucalyptographia," under the various Mallees (1879-84).

§ Forest Flora of South Australia, Part v. (1882).

A little later, Mr. Tepper, of Adelaide, offered another explanation of it*—"*Eucalyptus oleosa* is a species with an underground rootstock, from which numerous small stems, generally crooked and semi-sarmentose, spring. When these are destroyed by fire, &c , a host of fresh ones spring up from the caudex." But no details are given of the characters of the supposed rootstock.

We owe to Mr. N. B. McKay† an interesting description of the underground, composite, stem-encircling tumour of a Mallee, even though it is incomplete, inasmuch as no particulars about the shoots, or the incorporated roots are given. We have looked in vain, however, for a more satisfactory one. He says – "The indigenous timber-growths on the Mildura horticultural areas consist, for the most part, of blue bush, 'bull' mallee, balar, pine, and needle-bush. . . . . A well established bull mallee is a problem to the ordinary grubbing contractor. The butt is a great flattened bulb of curly timber, sometimes 8 or 10 feet through. It is set firmly into the soil, and even if all the roots were cut off, the tree would stand in its place just the same, as the upper growth is very insignificant compared with the base. Chopping mallee out is an obvious impossibility, and, as the wood is full of moisture, it would be an endless task to attempt burning it out. Dynamite and rack-a-rock have proved equally useless. Before, or rather behind, the traction-engine, the difficulty disappears. . . . . . When all the stumps are uprooted, the adhering earth is knocked off, and they are readily burned."

Three items in this are worth notice. Firstly, that the butt is a "flattened" bulb: that it is to say, it increases in size horizontally rather than vertically. Secondly, it is a bulb of "curly timber": it is not a case of a simple, localised thickening of the stem, but results from the proliferation of cambium-tissue. Thirdly, "the wood is full of moisture": it is a water-charged tumour, because of the incorporation of water-storing roots.

* "Remarks on the 'Manna' or Lerp Insect of South Australia." Journ. Linn. Soc. Lond., Zoology, xvii., p.109 (1883).

† Eighth Progress Report of the Royal Commission (of Victoria) on Vegetable Products, 1890.

The late Professor R. Tate, in a paper entitled "A Review of the Characters available for the Classification of the Eucalypts,"* etc., under the section "Habit," expressed some views, which should have provided a new starting-point for considering the make-up of the Mallees. Unfortunately, they were so severely condensed as to be cryptic, and quite failed to influence his successors. Tate says—

"The Eucalypti comprise two habits of growth, viz., trees and shrubby trees, to which I apply the vernacular names of *Gums* and *Mallees*. I do not know if I am correct in so doing, as I have failed to find any definitions of these well-known terms." "I have constantly observed in seedlings and growths of one or two years of such gums, as *E. rostrata*, *leucoxylon*, *viminalis*, a large inflation of the base of the stem, either at the surface or just below the surface of the soil. In the species named, this is eventually outgrown; but, in the mallees, it persists and increases in size proportionately with the development of the branches which are emitted from it—in the mallee, this rudely globose bole is partially subterranean."

It is the third and fourth sentences that are important. These embody Tate's version of the problem we are interested in, compressed to an irreducible minimum. The chief difficulty arises from the fact that no attempt is made to explain the nature or the significance of the basal inflations. A non-committal name is given to them, but they remain of problematical import. Nor is any reason given for their being transient in the seedlings of Non-Mallees, and persistent in the Mallees. Nevertheless, he recognised the difference. Apparently his seedlings were not young enough to show the axillary stem-nodules before they had fused in pairs, and the fused pairs had concresced; and they were not old enough to show that basal inflations were able to incorporate roots. It was, presumably, from necessity, and not from choice, that he confined his observations to seedlings of "one or two years." If he had mentioned this, and supplemented it by pointing out the importance of studying seedlings in trying to understand such complicated structures as the adult

* Report Aust. Assoc. Adv. Sci., vii., p.544 (1898).

Mallees present, those who came after him might have been induced to follow his lead, and to extend his incomplete observations. Even what he actually says ought to be sufficient to make anyone cautious about identifying the persistent basal inflation of the Mallees as a "rootstock," without first investigating the transient basal inflations of such Non-Mallees as have them.

Unfortunately his excessive reticence obscured what merit his observations may have; and his successors, in attempting to explain the make-up or constitution of the Mallees, either adopted Mr. Tepper's idea that the Mallees have "rootstocks," without offering any explanation of their peculiarities; or else they make use of one or other of the older definitions, which, though excusably deficient when they were first offered, are now out of date.

As far as we can ascertain, Mr. Maiden is the only writer who has taken any notice of Tate's statement quoted above. On the first page of his "Critical Revision of the Genus Eucalyptus" (1903), the author gives substantially Tate's views, almost in the original words, but without any comment other than "This classification is chiefly of practical use in Professor Tate's own State (South Australia) and in Western Australia."

In Plate 57, fig.12 (of Vol. ii.) of the same work (1911), an illustration of a young seedling of *E. paniculata*, with a pair of axillary stem-nodules still unfused, will be found. This, we believe, is the only illustration of a Eucalypt seedling with stem-nodules, or any stage of them, which has hitherto been published. In the explanation of the Plate (p.131), fig.12 is referred to as—"Bulbous swelling in seedling. . . . . . This swelling is very common in seedlings belonging to this genus, and the cause has not been investigated so far as I am aware. It is presumably to be attributed to the action of bacteria." Allowing for the fact that there is a pair of independent, bulbous swellings, and not merely one, and that they are the first stage in the formation of Tate's transient basal inflation of a Non-Mallee, we agree with Mr. Maiden that they are presumably attributable to the action of bacteria. But we should say exactly the same about a similar seedling of a Mallee, with the first pair of axillary nodules or bulbous swellings present.

The difficulty which confronts anyone who tries to interpret the axillary, bulbous swellings of seedlings of Eucalypts, whether Mallees or not, and Angophoras, from the standpoint that the Mallees have rootstocks, is exemplified by the following quotation from a recent paper by Dr. Hall*—"The origin of the peculiar rootstock of the Mallee can be well seen by observing the seedling. In nearly all the Eucalyptus seedlings, and also in the Angophoras, there is developed, especially if growth is checked, a small woody swelling in the stem at the point of attachment of the cotyledons. A number of buds will develop on this, and shoots start from them. If the growth of the seedling proceeds in the form of one main stem, this swelling is soon obliterated, but, in the Mallee, these secondary shoots grow almost as quickly as the main stem, and so, instead of a tree in the ordinary sense, we have an enlarged rootstock, from which spring numerous stems, all more or less of the same size." The author is here trying to explain Tate's problem of the transient and persistent basal inflations of the Non-Mallees and the Mallees. If the small woody swelling at the attachment of the cotyledons of the seedlings of Mallees is the initial stage in the formation of a persistent rootstock, is not the woody swelling of the seedling of Non-Mallee Eucalypts and Angophoras also the initial stage in the formation of a transient rootstock?

The following statement from Tubeuf and Smith's "Diseases of Plants" (p.299) may be mentioned. "In the Botanic Garden at Amsterdam, the roots of several species of *Eucalyptus* exhibited woody tumours from which proceeded outgrowths resembling 'witches' brooms.' These contained the mycelium of an *Ustilago* which produced spores in the cortical tissues." If the tumours here referred to are of the same kind as those we are interested in, we consider that the presence of Ustilago under the circumstances mentioned, is to be regarded as merely indicative of a saprophytic intruder. As pointed out by Erwin Smith and his colleagues, a varied assortment of lodgers commonly infest crown-galls.

* "The Evolution of the Eucalypts in relation to the Cotyledons and Seedlings." These Proceedings, 1914, p.517.

Non-Mallee Eucalypts.

Seedlings of some species of Eucalypts are exempt from tumours. We have met with six of these, referred to later on. As mentioned in our introductory remarks, tumours, which accomplish all they can do, pass through the three stages of—(1) axillary, shoot-bearing stem-nodules; (2) composite, shoot-bearing, stem-encircling tumours; and (3) composite, stem-encircling, shoot-bearing, root-incorporating tumours.

Axillary Stem-nodules.—Five young seedlings, with one or more pairs of stem-nodules, with the cotyledons, or some of the leaves *in situ*, are shown in Plate iv. The cotyledons and lowest leaves have usually disappeared by the time the nodules become recognisable, as in the two series of seedlings shown in Plate v. When they are absent, therefore, it is to be understood that the opposite and distichous arrangement of the nodules corresponds to a similar arrangement of the cotelydons and leaves, in whose axils the nodules developed. Figs. A1 and A2 are seedlings of *E. corymbosa*, each of which has only one pair of nodules. Both nodules of the older one have a shoot with several pairs of leaves. Older seedlings of this species are shown in Plate xi. Figs. B1, B2, and B3 are seedlings of *E. hemiphloia*, one with two, and two with four pairs of stem-nodules. These supplement the series of the upper row of Plate v.; they are shown here simply because they happen to have one or several leaves *in situ.*

The upper row of Plate v. shows a gradational series of five young seedlings of *E. hemiphloia* not old enough to show more than three pairs of nodules. The three youngest (from right to left) show the successive development of one, two, and three pairs of axillary nodules. The first pair of the second seedling have made good progress, and are obviously more advanced, that is older, than the second pair. This is not so evident in the third seedling, which has a bend in the axis. The fourth example shows a further advance. The nodules of the first pair have grown unequally, so that one is bigger than the other, though of the same age; while fusion between them has made some progress. The second and third pairs have made fair progress. The fifth example shows still further advance.

The first pair have nearly completed their fusion, except superficially; the second pair are still small; while the presence of the third pair, in the axils of the second pair of leaves, can be made out. One shoot has developed on each nodule of the first and second pairs. Another seedling with two pairs (B1), and two older ones with four pairs (B2 and B3) are shown in Plate iv. The first pair of B3 have made good progress, and have nearly completed their fusion. Another, but a rather poor specimen which could not be photographed while it was fresh, with five pairs of stem-nodules, and three root-nodules, is shown on the left of Plate xii. All the specimens of this series were nursery-seedlings; and we have been able to ascertain, that seedlings 3-4 months old, with from 4-7 pairs of foliage-leaves, may or may not have one pair of recognisable nodules. Bush-seedlings of *E. corymbosa*, about 3-4 months old, with four pairs of foliage-leaves, will usually show one pair of recognisable nodules, as in fig. A1.

The lower row of Plate v. shows a similar series of bush-seedlings of *E. sideroxylon*. The younger ones show, in order, one, two, and three pairs of stem-nodules. The fourth shows a more advanced stage of three pairs, the nodules of the second pair being about as large as those of the first. The fifth seedling has four pairs. One of the first pair has grown more than its fellow. One of the second pair seems to have come to a standstill, while the other has grown downwards into the interval between the nodules of the first pair, and shows signs of commencing to fuse with one of them. The third and fourth pairs are still small.

An interesting growing seedling of *E. tereticornis*, with three pairs of nodules, and no shoots, is shown in Plate vi., fig 2. The opposite and decussate arrangement of the pairs of nodules is well seen. The first pair have developed well, and fairly equally; and have fused basally, leaving only a superficial interval still to be filled. The visible member of the second pair is small, and seems likely to fuse with the first pair before fusing with its fellow. A notched, white card has been placed in position to give a white background.

The total number of pairs of stem-nodules present in seedlings depends on the number of axils affected, and on the age of the seedling. Seedlings of some species, as a rule, may have more than those of other species at about the same stage; but seedlings of the same species may similarly differ. Occasionally one may find a seedling of a species liable to have them, and old enough to show them, without any at all. One nodule of a pair is often missing. Apparently, therefore, sometimes the conditions which lead up to the production of nodules fail, or inoculation was prevented, or did not take place. Sometimes, after the first pair, the change from a pair of opposite, to two alternate leaves may result in the appearance of two incomplete pairs.

Plate vii. shows a set of miscellaneous, hardy bush-seedlings from poor virgin soil, which are remarkable for the numbers of pairs of axillary stem-nodules present; for the slow progress of the lower pairs in most of them, considering how many pairs are present, and consequently for delayed fusions and concrescences; and for variation in the lengthening of the internodes. The first five (left-right) are somewhat older than might be expected from their small size. The first three are *E. eugenioides*, the third of which shows fusions and concrescence of nodules, while the other two have done very little even in the fusion of nodules of the same pair. Some of them have shoots. One nodule on the lower side is missing from the third pair of the first seedling. The fourth and sixth are *E. piperita*, and show well, what is very characteristic of seedlings of this species, numerous pairs, most of which are crowded up through the non-lengthening of other internodes besides the first and second. A later stage is shown in Plate xii., fig.2; but, in this case, matters were complicated by the death of the seedling-stem at an early stage, and its replacement by two tumour-shoots, as is usual; these are remarkable for having pairs of axillary nodules (some stage of three pairs in each case) the lower ones fairly close together. Seedlings of this species sometimes have very shapely, large tumours.

The fifth and seventh are seedlings of *E. hæmastoma*. One nodule is missing from each of the fifth and sixth pairs of the smaller specimen. The larger one shows considerable lengthening of the third and fourth internodes; also a root-nodule (*r.n.*) from which on one side, near the base, a root (*r.*) emerges, which does not come out very well in the photograph. The nodules of the lowest pair furnish a good example of unequal progress.

The remarkable seedling in Plate x., fig.*a*, has eight pairs; the seventh and eighth are indicated, but had not completed their growth when the specimen was secured. This was a pot-seedling, about 2 feet high, and somewhat older than the others shown in Plates ix. and x. It is the most remarkable, refractory seedling we have seen.

The remarkable seedling of *E. eugenioides*, about 4 feet high, shown in Plate xix., has twenty nodules (possibly twenty-two), fourteen stem-nodules, in addition to the concrescence, comprising at least three pairs (possibly even four); four pairs are incomplete, one nodule of each having failed to develop—potentially about twelve pairs. The nodule marked 1 is solitary, and was about to fuse with the concrescence. The rest were not likely to have accomplished anything whatever, even in the way of fused pairs. Another, fine, but much younger specimen of the same species, about 2 feet high, has twelve pairs, but the uppermost are not very far advanced, and there are indications of some others to follow; the first three pairs have nearly completed their concrescence. This specimen was obtained too late to be included in the series shown in Plate vii. For its total number of complete pairs, this is the most remarkable seedling we have seen.

Sometimes, but rarely, an extra nodule makes its appearance, so that instead of the first pair, there is a whorl of three. When this happens, the second node may, or may not, also show a whorl of three. We have four seedlings, two of which show one whorl of three; and two have two whorls of three. The explanation of this condition is that the cotyledons of both Eucalypts and Angophoras occasionally show anomalies, such as three cotyledons, fused cotyledons, or with one cotyledon partially or completely "split." When this happens, the first pair of leaves may be normal, or dislocated, or replaced by a whorl of three leaves. The significance of these anomalies, for our purpose, is the provision of an additional one or two axils for the collection of soil or dust; or the loss of an axil.

Plate xi. shows a series of seedlings of two of the Bloodwoods (*E. corymbosa* and *E. eximia*) which differ from any other seedlings of Eucalypts that we have seen, in that they have, usually, only one pair of effective, axillary nodules, though there are sometimes two, and occasionally more in late stages; but they almost always have an unpaired, not definitely located nodule below the level of the cotyledons. Figs. 1 and 2 represent two young seedlings, somewhat older than the two shown in Plate iv. One of them has only one axillary nodule; we have other seedlings like it. Both are too young to show the unpaired nodule. When it does appear, it is sometimes much closer to the axillary nodules than at others. Occasionally, it is far enough away to indicate that it possibly developed on the taproot, rather than on the hypocotyl. It seems to be probably a case of wound-infection due to a possible tendency of the bark of these young seedlings to crack in growing. The nodule extends upwards, fusing harmoniously with the fused, axillary stem nodules; and grows downwards also, partially, or by degrees, entirely encircling the axis. The fusion usually ends abruptly. It may be an inch long, or four inches, and in one case about eight inches. In late stages, it increases in diameter, but continues to be cylindrical in shape. One specimen has two unpaired nodules, one below the other. The lower one is evidently a root-development.

The presence of more than one pair of axillary nodules is unusual in *E. corymbosa*. But we have one advanced seedling which has five pairs [first pair (one with a shoot) fused, and the fused pair fused with the unpaired nodule, as usual; one nodule of the second pair with a shoot, and fused with the concrescence, its fellow very small, and solitary; the nodules of the third, fourth, and fifth pairs small, unequally developed, and not fused].

One seedling of *E. eximia* (Plate xi., No.6) has two pairs of axillary nodules, which is unusual, (though we have another like it) and a pair of root-nodules; but, apparently, the unpaired nodule is absent in this case, unless it is represented by one of the root-nodules. Both root-nodules have incorporated a root, but that of the smaller one was accidentally broken off short, and its stump is hidden from view.

In seedlings of some species and in some individuals of the same species, the axillary stem-nodules appear sooner and progress faster, than is the case in others, or the period of incubation is shorter Sometimes this may be due, in some degree, to unfavourable conditions; but in other cases it seems to be a constitutional matter. Hence, it is possible to distinguish between susceptible, and resistant or refractory species, or individuals. The majority of the species whose seedlings are known to us, are susceptible, some more so than others The best examples of refractory species that we have met with are *E. robusta* and *E. longifolia*, of both of which we have seen nursery-seedlings in quantity; but we have been unable to get bush-seedlings. Advanced seedlings of these two species are shown in Plates ix. and x. The seedling of *E. robusta*, with eight pairs, (Plate x., fig. *a*) is the most remarkable refractory seedling we have seen.

Axillary nodules develop not only on the stems of seedlings, but also on tumour-shoots, showing that the first few leaf-axils of tumour-shoots repeat the conditions offered by the early axils of seedling-stems. Fig.3 (not numbered) of Pl. vi., shows the tumour of a seedling of *E. resinifera*, whose stem, with one pair of unincorporated nodules, and any shoots that may have been present, was scorched and killed by a bush-fire. Two tumour-shoots, as is usual in such a case if the seedling stem is centrally situated, replaced the stem; these were about 7 and 10 inches high, and were doing well when the specimen was taken. Both have the first pair fused with the tumour. The larger has a second pair, unfused, and unequally developed. The smaller has a second pair, one only of a third pair, a fourth pair, and also a fifth pair. [The numbers on the Plate indicate only the conspicuous ones; the fifth pair of the smaller one, not being very well shown in the photo, was not numbered]. The tumour itself may represent probably three fused and concresced pairs.

Another case is shown in fig.2 of Pl xii. This also is a case of two tumour-shoots taking the place of a seedling stem after injury, not by fire in this case. Each of them has three pairs of axillary nodules.

Still another case is illustrated in Pl. xviii. The large tumour-shoot at the back, a little to the left of the stem, has six nodules, of which four are visible—the first pair not fused; the second pair dislocated, probably due to a pair of leaves becoming alternate; one only of a third pair, and one of a fourth pair, with a shoot. Another tumour-shoot, hidden in the photo, also has a good pair.

These three seedlings show, then, that axillary nodules may develop on tumour-shoots which develop in the ordinary way, or on second-growth shoots, whose development has been accidentally stimulated.

The Nodule-Shoots.—Until the morphology of the seedlings, and the histology of the nodules and composite tumours have been investigated, one can attempt to interpret macroscopic characters only with reserve. The shoot-bearing character of the nodules is due to the fact that the axillary outgrowths take over and incorporate the dormant buds (or the bud-forming tissue), which, otherwise, would be smothered. But so many shoots sometimes develop on a single nodule, or on a fused pair, that we are inclined to think that the nodules sometimes carry away bud-forming tissue, rather than simply differentiated buds; and that the stimulus which is responsible for the proliferation of the cambium to form the nodules, may also cause the bud-forming tissue to proliferate and spread.

On the other hand, sometimes the growing nodules fail to take over the buds. Three good examples are shown in the two Stringybark seedlings in Pl. xii. Another is shown on the stem of the seedling of fig.1 of Pl. xiv. Also two others in the refractory seedling, *c*2 of Pl. x.; for the two futile nodules of the third pair, and the two branches just above them, belong to the same pair of axils. There are some other examples on the remarkable seedling in Pl. xviii., particularly the pair of which one is numbered 4. In such cases, the bud and the nodule develop separately; if the bud perishes, the nodule is left stranded on the stem. If both develop successfully, it is noticeable that the nodule is usually on the outer side of the branch in the external angle between the branch and the stem, fused to both. This suggests that, as the nodule develops on the outside of the bud, and between the latter and the attachment of the peticle of the leaf, the supposed weak spot in the axils, which makes inoculation possible, may arise in connection with the differentiation of the bud; or that there may be a weak spot about the attachment of the petiole, which is exposed when the leaf expands; or, perhaps, both are concerned. Serial, transverse, and longitudinal sections are required to settle the matter.

In general, the conditions which favour or retard the development of ordinary branches in leaf-axils, favour or retard the development of nodule-shoots; and, particularly, sufficient room to allow of free exposure of the plants to light; and damage to the growing-point, or removal of the greater part of the stem. Defoliation, under some conditions, may also stimulate the production of nodule-shoots.

Two very young seedlings of *E. hemiphloia*, with only the first pair of stem-nodules present, are shown in figs. C1 and C.2 of Plate iv. One shoot promptly developed on each nodule after the growing-points suffered injury, in each case. Sometimes two, or even three, shoots will develop on at least one nodule of seedlings like these.

Pl. xxv., fig.1, shows a flourishing pot-plant of *E. tereticornis*, growing under very favourable conditions, which exhibits profuse branching, as well as nodule-shoots.

An advanced pot-seedling of *E. hemiphloia*, with a well-developed, complete encircling tumour, without any shoots, was unintentionally neglected, and the pot allowed to become so dry, that the leaves wilted, and were cast off. On receiving attention, the plant revived; but, before the new leaves appeared, five young shoots promptly developed on the tumour.

Though the buds usually remain dormant on the nodules of refractory seedlings like those shown in Plates ix. and x., injury to the growing-point, or removal of the greater port of the stem will cause shoots to develop.

The presence of shoots is of great importance both to the stem-nodules, and to the resulting, composite tumours, for they are not then entirely dependent on the seedling-stem for nutriment. A large, revived, belated nodule (A2), whose fellow is missing, is shown on the advanced seedling in Pl. xix. The seedling-stem (*s.st.*) perished, whereupon the main nodule-shoot took up the running, and this gave the nodule a chance of making a fresh start. This is the largest, individual nodule we have yet seen. The photo is reduced by somewhat more than one-third. Composite tumours at first are usually more or less pyriform in shape, especially if they have no shoots, or only insignificant ones (Pl. xii., fig. on the right). Some of the later stages of the *E. sideroxylon*-series show how the upper portion of the tumour fills out when there is a good series of shoots round the summit. As long as the shoots last, and continue to grow, the composite tumours may be expected to progress proportionately.

The number of nodule-bearing shoots on a seedling, like the number of shoots on individual nodules, if the conditions are favourable, is sometimes surprising. The oldest nodules are likely to show them first, and to have most shoots. The basal pair, or only one of them, will very often show one or more, when the others are without them. But the nodules of any pair, or one of them, may have shoots, when the others have none. Both, or one, of several pairs may have at least one shoot. Or the buds may remain dormant, and no shoots at all may develop, as in most refractory seedlings.

It would be unusual to find more than one branch in a leaf-axil, though, of course, there may be reserve-buds. Three shoots are often present on a single nodule, but there may be as many as seven, or even more, in different stages. Fig. 1 of Pl. vi., shows a very attractive bush-seedling of *Angophora lanceolata*, probably not under two years old, photographed while fresh. As shown, it is less than half the natural size, the stem-height above the encircling tumour being about 10½ inches. The tumour is the result of the complete fusion of the first pair only. The nodules of the second pair, still very small, unfused, and without shoots, are to be seen, rather indistinctly, a little above, but there is no third pair. Eight shoots are present, four on each side, but two of one group are dead.

An inspection of the figures of the *E. sideroxylon*-series will give an idea of the way in which shoots develop about the summit of the tumours, when they are complete in late stages When specimens like these are scorched by a bush-fire, and the stem, and any shoots that may be present, are killed, provided, of course, that the underground portions, including the tumours, are not hopelessly injured, fresh second-growth shoots may come up freely, when the conditions become favourable. Fig.3 of Pl. vi., is an example of a scorched seedling. Two second-growth shoots only are present here. The growth-habit of such plants, especially if they are scorched a second time, or oftener, and recover, if they succeed in attaining any size, necessarily is much modified. In the quotation from Mr. Tepper's paper, the second-growth shoots of the Mallees, under similar circumstances, are mentioned.

The shoots of all the pairs except those which supply them at the summit of late stages of the encircling tumours, are doomed to perish at an early stage, except under exceptional circumstances, because the tumours are gradually pulled underground. Even those on the summit cannot last indefinitely, as a rule, unless water-storage roots are incorporated.

The nodules, when quite small, are smooth. As they increase in size, the surface becomes warty, due to local proliferation. As the warty protuberances increase in size, they meet and fuse, and fill up the vacant spaces. In this manner, by constant local proliferation at the periphery, the nodules, or the composite tumours to which they give rise, increase in size. The latter, when doing well, are excessively warty. This is indicated in some of our illustrations, but the warts do not always show up as conspicuously as they do in the specimens.

The nodules and the surface of tumours, when fresh, are readily sliced with a knife; but, when dry, they are hard and woody. The tumours when fresh, and doing well, contain a good deal of moisture; but, when drying, gaping, longitudinal cracks, often from top to bottom, appear.

Later Stages.—Growing nodules very readily fuse with any other suitable living tissue with which they make contact; so that finally, when the fusion is complete, there is no visible line of demarcation. As the nodules of a flourishing pair progress, they increase steadily in size, growing upwards slightly, but more evidently outwards, backwards, and downwards, until they meet and fuse, thus encircling the stem. Similarly the fused pairs grow downwards, covering up and fusing with the portion of the stem involved, until the several fused pairs have concresced. As the basal portion of the concrescence grows downwards, it finally encircles and fuses with the upper portion of the taproot, and the proximal portions of any lateral roots that it may encounter. We have an example of two seedlings growing so close together that the encircling tumours came into contact and fused. If two such seedlings survived and attained tree-size, they might furnish an example of apparently one tree with two stems.

The opposite and decussate arrangement of the stem-nodules, corresponding to the disposition of the cotyledons and leaves, is an ideal arrangement for the production of well-balanced, symmetrical, composite, encircling tumours, provided—(1) that all the pairs of stem-nodules are complete; (2) that the nodules develop promptly; (3) that they grow comparatively equally and uniformly, and make the necessary fusions, and the fused pairs the necessary concrescences, at the right time, and in the right way; and (4) that the internodes, especially the lower ones, do not lengthen too soon or too much. But if one or several of these provisoes fail, the final result will be correspondingly modified. If plenty of material is available, very suggestive and instructive anomalies, of almost every conceivable kind, may be obtained.

Incomplete pairs of nodules are common. If several nodules or pairs are missing, any resulting composite tumour will be correspondingly smaller. A good example is shown in Pl. xiii., fig.2, of the *E. sideroxylon*-series (about half nat. size). This is a concrescence of the fused first pair and of one nodule only of the second pair, and this, though it is included, did not make much progress and contributed very little, and is still recognisable (in the specimen though not in the photograph).

One nodule missing from the first pair, which is chiefly responsible for the basal portion of the encircling tumour, is a fruitful cause of the production of lopsided tumours. An example is shown in Pl. xiv., fig.3, in which the left nodule of the first pair is missing. Unfortunately the photograph is slightly blurred. A missing nodule from the uppermost pair, may interfere with the symmetry of the summit of the tumour. We have a seedling with three incomplete pairs only, one nodule from the top and the bottom pairs on the same side being missing. At the best, all that these could give rise to, is a half-encircling tumour.

Fig. *c* of Pl. viii., appears to be a case in which one nodule of the first pair (on the left) did not develop. The seedling-stem having been broken off, a normal branch in the axil without a nodule then assumed the erect position, and took the place of the seedling stem. The single nodule present, made fair progress. It shows indications of about a dozen shoots, some of them dead. The large shoot, just to the left of the stump of the stem, belongs to the latter.

Sometimes a nodule, instead of growing downwards and fusing with the stem, will grow downwards and outwards, away from the stem, even in erect seedlings. Three bent seedlings are shown in Pl. viii. They have stem-encircling tumours, resulting from the fusion of the first pair, which has grown outwards and downwards away from the stem. There is only one pair in fig.*a*. Figs. *b*1, *b*2, show some indication of others poorly developed. There are no incorporated roots in these specimens, nor, we think, was there any likelihood of its happening. In arranging the specimens for being photographed, some of the lateral roots were unintentionally left in unnatural positions.

Inequality in the comparative rate of growth of the nodules of the same pair, as well as in the comparative growth of successive pairs, is also a fruitful source of anomalous developments. One nodule of a pair may come to a standstill, while the other goes on growing; or both may progress, but one of them faster than its fellow (as in No.7 of Pl. vii.). Nodules of the same pair may fuse sooner on one side than on the other; or they may fail to fuse at all on one side. Encircling tumours, as they grow downwards, may progress faster on one side than on the other.

If the nodules do not develop promptly, while the tissues are quite young, that is, if the period of incubation is longer than usual, the nodules seem to make slower progress, when they do appear. Meanwhile, the lower internodes may have lengthened to such an extent that the concrescence of pairs may be delayed or even prevented. Angophora seedlings frequently offer very characteristic examples of this kind of thing.

The *E. sideroxylon*-series (Pl. v., lower row, and Pls. xiii.-xvii.), of which the earliest, the last, and as many intermediate stages, as space will allow, are shown, are intended to indicate the course of events in a susceptible species. With the exception of the tumour in Pl. xvii., all the photographs were taken when the specimens were fresh. They are variously reduced, from about one-third to one-half, or even more in the larger ones. They are intended to show the composite tumours, with recognisable portions of the seedling-stems and tumour-shoots, and, especially, various stages in the capture of lateral roots.

The smaller of the two crossed seedlings (Pl. xiv., fig.2) shows the first and second fused pairs of nodules concresced; the third pair have not yet completely fused; one nodule from the fourth pair is missing. The growing-point was injured. The taproot is caught between a lateral root and the tumour, so that it cannot be freed without trimming the latter. There was enough soil between the two tumours to prevent fusion. The larger specimen has lost its seedling-stem, and two of the tumour-shoots, one on each side, are taking the lead. No roots had been incorporated in either specimen.

The seedling in Pl. xiii., fig.1, with a stem-height of 20 inches, has three pairs almost completely concresced, and two pairs not yet fused. Two roots are just incorporated, and another was ready to be.

The two seedlings on the right (Pl. xiii., fig.3) show incomplete concrescences at the top; and an early stage of the incorporation of a root.

Fig.2 of the same Plate (reduced by nearly one-half) is a fine seedling, with a stem-height of 37 inches, the two longest tumour-shoots about 13 inches. It is a good example of a small tumour resulting from a shortage of axillary nodules. Only three developed, of which the only one of the second pair (hidden at the back of the photo) made little progress, and contributed practically nothing to the tumour. Small though it is, the tumour has captured three good, lateral roots Two others, which were accidentally broken off, and whose bases are hidden by the lateral root on the right, were about to be captured. The seedling-stem had a good canopy of foliage, and had got well ahead of the tumour-shoots, so that it would probab y have got rid of the latter sooner than seedlings with larger tumours.

The seedling in fig.1, Pl. xiv., (reduced by about one-half) has a concrescence of probably two pairs, with three incomplete pairs above (one of which is hidden). The downward growth of the concrescence on one side, is much in advance of that of the other, as shown on the left. The uppermost is a good example of a belated nodule which failed to get possession of the bud; both it, and the branch above it, belong to the same axil. Several of the shoots have done well. Two lateral roots have been incorporated; and several others would have been later on.

Fig.3 of Pl. xiv., is an example of a lopsided tumour due to the absence of one nodule of the first pair. Unfortunately the photo is slightly blurred. It has not incorporated any roots. Shoots are numerous. The seedling-stem may possibly be missing.

Fig.1. of Pl. xv., is a very complete concrescence (reduced by somewhat over one-third). Two lateral roots are just incorporated.

Fig.2 of the same Plate (only slightly reduced) has the concrescence incomplete behind except at the top. One good root has been incorporated on the right. The root on the left with a bifurcation, and the one above it, would have been incorporated if the concrescence had been complete behind.

Fig.3 of Pl. xv., is a good example of a late stage.

Fig.1 of Pl. xvi , shows a fine seedling, with a stem-height of 5 feet above the tumour. The latter is shown (nat size) in Pl. xvii. The strongly developed taproot is now well established, the lateral roots being insignificant by comparison. The seedling-stem has been able to increase its initial lead, and to develop its upper branches, so that their crown of foliage fairly completely overshadows the tumour-shoots, preparatory to getting rid of them by the process of natural pruning. The lateral roots are so insignificant that the tumour must be largely dependent on the seedling-stem for most of its water. When the leaves of the crown of foliage belonging to the seedling-stem and its branches have overshadowed the tumour-shoots, and are transpiring freely, the latter seem to suffer in consequence. When the shoots have been got rid of, the tumour, as such, gradually comes to a standstill. The tumour of this example is shown in Pl. xvii. (nat. size), and is a fine specimen.

Fig.2 of Pl. xvi., shows the size of two, more advanced seedlings, 6-7 feet high, side by side. The one on the left, which had got rid of its tumour-shoots, was dug up (inadvertently the taproot was cut off rather too short), and held beside a slightly taller, undisturbed specimen, which had one shoot left. This was afterwards uprooted and examined. It will be noticed that, at this stage, the tumour is completely out of sight underground. These photos were taken early in October, 1914, at which time the plants were about six years old. Three and a half years later, other examples of the same batch as those in fig.2, were promising saplings 9-12 feet high.

The last stage of an advanced seedling of *E. tereticornis* is shown in fig.2 of Pl. xxi.; this has one small shoot left. The plant was uprooted carefully, placed on a stump, and photographed immediately. It was growing near the specimens shown in Pl xvi. In this case, the seedling-stem appears to be excentric, consequent upon lopsided growth of the tumour; and the shoots were all on one side. One nodule was not incorporated in the tumour. The difference in size between the taproot and the incorporated or other lateral roots is well shown.

Pl. xx., shows another but older stage of the same species; but, in this case, matters are complicated by the death of the seedling-stem. A few inches of the latter were *in situ* when the plant was found, but were accidentally broken off in packing-up a number of specimens. The stump of it is just discernible in the photo. There were a number of shoots, but, in this case, one of them took the lead, and was 6 feet high. At the base of it is a remarkable, encircling insect-gall. At first, we took this to be a case of the fusion of pairs of axillary nodules on a tumour-shoot, followed by concrescence; and that it might be an example of what Tate meant, when he said seedlings and "growths" have basal inflations. On cutting it transversely, four radial cavities were exposed, two of which contained living coleopterous pupæ, one in each cavity; the other two contained only exuviæ or excrement. Apparently, the mother-insect oviposited at intervals all round the base of the shoot.

Of the two advanced seedlings of *E. eugenioides* in Plates xviii. and xix., the first has not yet got rid of the tumour-shoots, which are situated at the back, as the specimen is shown. The other one had got rid of them; in this case, the death of the seedling-stem gave rise to complications.

Tate, in his brief way, said that Non-Mallees, which have basal inflations, grow out of them. Apparently, he was relying on experience, and not speaking from observation. The only author who mentions what takes place, as far as we can find, is Ednie Brown, who in his "Forest Flora of S.A.", under *E. leucoxylon* (Part ii.), says—"During the first two years of its growth, the plant has a low-lying or spreading habit, not at all prepossessing in its favour, when looked upon in the light of a future timber-tree. About the third year, however, a straight and upright 'leader' comes away from the centre of the apparent bush, which, after this, soon assumes the form of a promising young tree."

What is here described as a straight and upright leader, is simply the seedling-stem coming into its own, and getting rid of the tumour-shoots. Otherwise, if the seedling-stem is destroyed, two, strong leaders usually come away; that is two, tumour-shoots take the lead, as we have already pointed out, and as is shown in several of our Plates. The author was apparently not aware of the presence of what Tate, some years afterwards, called the basal inflation of seedlings of this species. We should think, also, that he probably underestimated the age of his plants.

Mallees.

The Mallee-Scrubs of the interior, where alone fruitful investigation can be carried out, are remote from, and inaccessible to us; and, consequently, our material for the study of the tumours of this group is very incomplete. Nevertheless, there is something to be learnt from it We regret that we have been unable to procure seedlings of the big Mallees, such as *E. oleosa*, *E. dumosa*, and several others

Plate xx., shows four advanced seedlings of three species. Figs. 1*a* and 1*b* are seedlings of *E. stricta* from the higher part of the Blue Mountains (about 3,000 feet), 2½-3 feet high, from a batch of seedlings, that we had had under observation for three years, from the time when they were too young to show nodules. The younger one (1*a*) has five pairs of axillary stem-nodules, the concrescence of the three oldest pairs not yet completed. The lengthening of the third and fourth internodes has kept the two upper pairs apart. Another example, about the same size, has a more complete concrescence of three or four pairs, then two incomplete pairs separated by the lengthening of the internodes; and above, two pairs, close together, followed by an incomplete pair; but all these are small, and there are no fusions among them. The older one (1*b*) has a more complete concrescence in the aspect shown; but one nodule of the first pair is missing (at the back), and the encircling tumour is consequently lopsided, and smaller than it otherwise would have been. Three and a half pairs seem to be present, and a fifth, small pair, doing little, are indicated at a higher level. One shoot is present, and one root was in process of incorporation.

Fig.2 is a seedling of *E. Moorei*, about 2 feet high, also from the Blue Mountains. The concresced portion, not quite complete at the summit, represents three or possibly four pairs. The uppermost pair is incomplete, the nodule at the back missing. We have younger seedlings of both species in various stages with up to five and six unfused pairs. We are inclined to think that the slow progress of the nodules of the seedlings of these two species is, in some degree, due to the low ground-temperatures and frequent frosts on the higher part of the Blue Mountains during the months of April-October.

Fig. 3 is a seedling of *E. fruticetorum* from Wyalong, for which we are indebted to Mr. Cambage—the only seedling he could find. We cannot make out the presence of more than one pair of stem-nodules, which fused on one side (in front, in the photo), but not on the other. The interval separating them at the back is about ¼ inch wide; and there is a depression at the top which is suggestive of the loss of a branch. The tumour had about eight shoots, and there are three branches low down on the stem. No roots had been incorporated. One specimen is not enough to enable one to judge whether this is merely an exceptional case, or whether one pair is the usual number for this species. The "Mallee-root" shown in Pl. xxiv., also from Wyalong, likewise has a tumour of one pair not fused on one side. We do not know the species, but it may perhaps be *E. fruticetorum*; and represent the latest stage of a seedling like Fig.3.

Plate xxi , fig.3, shows the most satisfactory example we have had from Wyalong (much reduced). This is a specimen of one of the small Whipstick Mallees (*E. viridis*) locally called Blueleaf-Mallee. For the stage at which it has arrived, it may probably be regarded as a fair example of a susceptible Mallee. It is not as plump as it might be, but it was collected in a drought. It was trimmed for convenience in transmission to Sydney, but the following dimensions may help to understand its importance: stem-height above tumour, about 6½ inches; diameter of stem above tumour, ½; length of tumour, about 3¾; diameter, 1¾; diameter of taproot below tumour, $\frac{9}{10}$. The best aspect of it is shown; at the back, the downward growth is not so satisfactory as in front. The seedling-stem appears to be excentric because of the smaller development on the right side. It has two branches low down; and there are three tumour-shoots. Four lateral roots have been incorporated; but they are insignificant in comparison with the well-developed taproot. All the stem-nodules have been included; the concrescence may well represent five pairs; there is a cavity near the summit, which appears to have been caused by borers.

Fig.1 of Pl. xxi., shows the youngest of four examples of *E. Behriana*, received from Wyalong. Unfortunately, the stem of every one of these was hopelessly damaged; and consequently the specimens are not typical examples, but they are all we can get. The youngest (× ½ about) has the seedling-stem broken off short, just above the level of the second pair of stem-nodules, one of which is now missing. The nodules of the first pair are back and front, and unfused. The posterior one has one shoot. The front one also had one, but this was broken off short. The surviving nodule of the second pair developed five shoots, the largest of which has two branches, and made good progress. It has fused with the nodules of the first pair, and has grown downwards to much below the level of the first pair. This nodule and its shoots were keeping the plant going.

Two older examples differ in age. The smaller has half an inch of the stump of the stem left. There appear to be two pairs of nodules. The first pair made some progress, but did not fuse. One of them has three shoots, two of which are 5·6 inches long. This nodule was keeping the plant going. One of the second pair fused with the nodule with shoots; the other made little progress. The bark on the nodules is very thick, and adherent.

The larger one is more difficult to understand, as the stem is almost completely missing. There are shoots up to 10 inches, in two places, on the margin of what is left. There is one pair of futile nodules, one much better developed than the other, on opposite sides of what is left of the stem, which is about 1 inch thick. Both this specimen and the preceding one have a long piece of the root intact. The smaller one has two, nearly opposite, lateral roots, and one above and one below these, not far away. But the larger one has three promising lateral roots at different levels, two on opposite sides of the taproot, and a middle one in a direction at right angles. An encircling tumour would have to make considerable growth before incorporating all of them.

For the large specimen shown in Pl. xxiii., in the natural position, as we think (rather than viewed with the taproot vertical), we are again indebted to Mr. Cambage. The best aspect of it is shown. A farmer, in grubbing up the plant, with one blow from his axe, delivered just behind the base of the big shoot shown in the figure, split off a large piece at the back, on which there was probably another shoot, situated on the right of the base of the dead seedling-stem. At the back, just to the left of the mark X on the photo, there is a longitudinal concavity, showing the site of the missing shoot. The remains of the original stem, now exhibiting signs of decay, indicate that it must have been about 3 inches in diameter when it perished. The taproot is well developed. One lateral root, with a branch, is seen to the right. This can hardly be said to be incorporated. At the back, there are four roots or indications of them, one of which is incorporated, and one partially, while two others are too low down. The development of the shoot present evidently stimulated the growth of the tumour all round its base. The rest seems to have come to a standstill after the death of the seedling-stem. What strikes us about this specimen, is the paucity of shoots; and that there is not such a satisfactory arrangement of lateral roots, at about the same level, as is shown in the specimen in Pl. xxiv. The loss of the seedling-stem doubtless complicated matters, and makes the interpretation of this incomplete specimen difficult.

E. Behriana is described as being sometimes a Mallee, 8-15 feet high, and sometimes a tree up to about 35 feet high. Our four specimens seem to us to be more or less refractory cases, whose root-system is not quite like that of the typical Mallees, in respect of the main lateral roots advantageously situated for incorporation in the encircling tumours. If either or both these conditions occur often, such may be responsible for the fact that *E. Behriana* is sometimes a tree. This species is well worth investigation with adequate material.

Magarey,* in describing the method of the Blacks in obtaining water from the roots of the Mallees, says—"The roots of these water-trees run out from the stem for 40 feet to 80 feet, and lie at a depth only of from 2 inches to 9 inches below the surface. The position of these lateral roots is frequently marked by a 'rise' or 'bulge' of the soil right over the root. The roots are

* "Australian Aborigines' Water-Quest." Proc. R. Geog. of Aust., South Australian Branch, iii., p.67 (1899). Also Rept. Aust. Assoc. Adv. Sci., vi., 1895, p.647.

easily raised. A native goes to a water-tree, and tries the ground at from 4 ft. to 5 ft. from the stem; or if guided by a 'bulge' or a 'crack,' finds the root at once" (p.69). . . . . "Each such mallee tree has usually from four or five to seven or eight side-roots running out from the stem at a few inches' depth from the surface" (p.70).

Plate xxii. shows a "Mallee-root." We do not know the species, but it was one of the smaller ones, and may, perhaps, be *E. fruticetorum*. It is not a particularly fine specimen, but it is the only one we can get. In the absence of any published illustration of the kind, as far as we know, we make no apology for showing this one; as there is something to be learnt from it, as there is from any undamaged "Mallee-root." The specimen was placed on its side, and photographed from in front. The scale is shown by the rule at the bottom. We interpret this to be a case of a not quite completely encircling tumour, resulting from one pair of stem-nodules which fused on one side (at the top of the photo), but did not fuse on the other side; hence the breach in the continuity of the tumour (at the bottom). There are four, important, more or less horizontally running, lateral, water-storing roots, two (at the top) coming off very close together; and two others (below) at a fairly wide angle. They are almost on the same level round the taproot. The tumour, composed of only one pair of nodules, was unable to encircle any of them completely; but it fused with the upper part of all of them, sufficiently, probably, to tap the water. The site of the seedling-stem is indicated by the light spot, which represents the posterior aperture of the hollow, flattened taproot, of which about six inches are left. The site of one shoot is well shown, over the lower lateral root on the right. The rest of the upper part of the tumour was so badly smashed, that it is difficult to locate exactly the situation of any other shoots that may have been present; but, notwithstanding the fact that the two upper roots are very close together at their junctions with the taproot, we believe that there was one over each of the other lateral roots. It seems, to us, a reasonable conclusion, that an uninjured, flourishing Mallee will, as a rule, have as many shoots as there are lateral, water-storing roots wholly or partially incorporated in the encircling tumour, and that the former are situated over the latter.

In an adult Mallee, the shoots and the stem, if present, are all approximately the same height, and diameter. But in the seedling shown in Pl. xxi., fig.3, the seedling-stem has so far maintained its initial lead. There must be some intermediate stage, therefore, when the shoots are able to overhaul the stem. Possibly this may come about when the lateral, water-storing roots are sufficiently developed, to supply more water in the aggregate, than the taproot alone is able to do. Such questions as these cannot be profitably discussed without satisfactory material, and observation on Scrub plants.

F. Mueller, Maiden, and Cambage, and others, have recorded instances of Eucalypts of species which are ordinarily Mallees, sometimes being trees; but we have failed to find any explanation of such cases. From our point of view, it is not difficult to understand that infection may fail to take place occasionally, or that, from accidental causes, or because the individuals were refractory, it may have been followed by little in the way of results.

The root-waterstoring arrangements of Eucalypts, whether Mallees or not, as well as of other Australian plants, in arid regions, are in need of scientific investigation. Little is known of this important subject, beyond what explorers, travellers, and early colonists gleaned from the Blacks, and have put on record. Naturally the Blacks chose the roots of the big Mallees. But it is a reasonable supposition, in the absence of scientific evidence, that the smaller Whipstick Mallees also stored water, though not on a scale sufficient for the Blacks to attempt to exploit it. Inferentially, all the Mallees must have water-storing roots, otherwise it is inexplicable how the tumours of the Mallees can keep their shoots, and persist.

Eucalypts may have water-storing roots, however, without being Mallees. The only author who mentions this fact, that we are aware of, is K. H. Bennett. In his description of the method of obtaining water from Eucalypt roots, as practised by the Aborigines of the arid country between the Lachlan and Darling Rivers,* he says "The Eucalypti consist of a gum (the

* These Proceedings, 1883, viii., p.214.

largest of the back country trees), a box, and a mallee. The first-named was the most preferred, as yielding the greatest quantity." The name of the species is not given, but it is said somewhat to resemble "the red gum in appearance—the leaves being narrower and of a silvery colour," and to grow "chiefly on sandy or light loamy soil, and throws out numerous lateral roots at a depth of from six to twelve inches from the surface of the ground." As the Blacks could not get at the water in the water-charged tumours of the Mallees, it is intelligible enough that they preferred to operate on the roots of a water-storing Gum. It is desirable that seedlings of this species should be examined, so that it may be determined whether they are exempt from axillary stem-nodules, or refractory; or, if susceptible, how they are able to get rid of the tumour-shoots. Seedlings of some of the Eucalypts of Central Australia mentioned in Spencer and Gillen's "Across Australia," also are well worth attention, particularly those of *E. terminalis* and *E. eudesmoides*, because these, perhaps, may be examples of water-storing Gums, like Bennett's.

We are not aware that analyses of the root-water of the Mallees have been published. Magarey mentions that, when freshly obtained, the root-water is clear, but that, after standing for some time, it becomes discoloured, and turbid (*l.c*, p.70). Is the turbidity merely due to a chemical precipitate on exposure to the air, or is it a biological phenomenon?

Another matter that is deserving of consideration is, the possible significance of the abundance of Lerp-manna on the foliage of some of the Mallees, at certain seasons and under certain conditions, as indicating the presence of some form of sugar in the sap, likely to be a source of nutriment to parasitic microbes. Particulars about its occurrence are given by Tepper, in the paper already mentioned; and in the Catalogue of the Victorian Exhibition, 1861, Report on Class iii., p.25, under the head of "Manna."

Pl. xxv., fig.2, and Pl. xxvi., show views of two growing Mallees, with as much soil, as was possible with pocket-knives and hands, scraped away from the base. The first and second of the three probably represent *E. oleosa*. They were taken in the Scrub, 50 miles north of Adelaide, by Mr. A. G. Edquist, to whom we are indebted for them. The third, in which the handkerchiefs of the party formed the background, is of a Mallee (*E.* sp.) at Wyalong, for which we are indebted to Mr. W. J. Moffat, who also, most kindly, did his best to obtain seedlings at Wyalong for us, and who sent us the Mallee-root figured. The published illustrations of Mallees, that we have seen, fail to give any idea of what is out of sight underground.

Angophoras.

We have obtained good series of seedlings of four species, *A. cordifolia*, *A. intermedia*, *A. lanceolata*, and *A. subvelutina*. They are alike, in that they are somewhat refractory. The stem-nodules are slow in appearing, that is the incubation-period is longer than in the Eucalypts we know best. Some bush-seedlings of a batch, that were over a year old, showed just recognisable stem-nodules; but others showed nothing at all. Nevertheless, when they are old enough, it would be surprising to find them without some. The nodules are not only slow in appearing, but they grow rather slowly after they do appear. Hence it is common to find examples on which only the first pair have fused (Pl. vi., fig.1); and one of these often grows more than the other, so that the fusions are lopsided. Meantime, the internodes have had time to lengthen, so that, even if there were fusions of the pairs above the first, there is little chance of concrescences. We have some advanced seedlings, however, which show large and complete tumours. Anomalies are common. We have one seedling with six incomplete pairs, and nothing else. We have not seen young root-nodules, like those figured in three Eucalypt seedlings; and we have not seen later stages of them in Eucalypts. But we have examples of Angophora seedlings with what appear to be late stages, unmistakably on the root, and incorporating roots.

Though, in this paper, we are confining our attention to Eucalypts and Angophoras, we may just mention that we have specimens of about ten species of other genera which appear to be similarly afflicted. We have been able to get young stages, with paired, axillary nodules, of some of them; but it is difficult to get young enough seedlings of the others. We hope to offer some observations on these on another occasion.

List of Species, exempt or liable, as far as known.

We give a list of the species of which we have seen seedlings, or in two cases, of seedlings which have come under the notice of Mr. Cambage. We offer this list in the hope that biologists in the other States will investigate the condition of the seedlings of Eucalypts accessible to them, which we cannot get, and, especially seedlings of the Mallees; and record their observations.

Group i., *Exempt Species.*—Six species are known to us at present—*E. oreades* from the Blue Mountains, *E. pilularis*, *E. punctata*, *E.* sp., from the foot of the Blue Mountains on the western side; together with *E. gigantea* Hooker (*E. Delegatensis* R. T. Baker), and *E. fastigata*, both from the Federal Capital Territory [collected by Mr. Cambage]. We have obtained seedlings of the first two in abundance; of the third, a fair number; of the fourth, only one, but it is a fine example. Mr. Cambage has kindly given us four examples of *E. gigantea*, and twelve of *E. fastigata*, most of them quite old enough to show that they are free from stem-nodules.

The seedlings of these six species, as far as we have seen, are exempt from stem-nodules. We prefer to speak of them as exempt, rather than as immune, until their axillary conditions have been investigated, and inoculations carried out. The seedlings of *E. oreades*, as well as the two lots of Mr. Cambage's seedlings, up to the stage presented, are just ordinary seedlings, inviting no comment. But seedlings of *E. pilularis*, *E. punctata*, and *E.* sp., as they increase in size, invariably as far as we have seen, gradually come to show a pyriform thickening of the base of the stem (of the wood to some extent, but especially of the bark, as may be seen in transverse sections) over a distance of several inches, according to age. This is not pathological, and seems capable of a simple explanation. The capacity of the root-system of these seedlings for receiving the elaborated sap seems to be unequal to the capacity of the stem for delivering it; so that there appears to be a stagnation of the sap about the base of the stem, such as might be caused by a constriction or a cincture. The enlargement of the stem ends at its junction with the taproot, and does not involve the lateral roots. Transverse cracks appear in the bark, and flakes often come away, when large specimens are dried, though the wood does not crack. But the large, composite tumours of seedlings liable to them, crack longitudinally, sometimes almost to the centre, when drying, as already mentioned. Mr. Cambage's specimens are not old enough to show this development, if they have it in later stages.

Group ii.—Two Bloodwoods, *E. corymbosa* and *E. eximia*, which have but one effective pair of axillary stem-nodules, as a rule; though other unimportant ones may appear in late stages; but the fusion of this pair, almost invariably fuses with an indefinitely located, unpaired nodule at a lower level; and the resulting, composite tumour extends downwards, partially or entirely surrounding the axis, and incorporating lateral roots.

Group iii.—Species liable to attack, but susceptible or refractory in varying degrees. This group will include all the Mallees, and the three species mentioned by Tate (*E. viminalis*, *E. rostrata*, and *E. leucoxylon*), of which we have not seen specimens.

County of Cumberland and the Blue Mountains.—*E. hæmastoma*, *E. tereticornis*, *E. Deanei*, *E. saligna*, *E. maculosa*, *E. rubida*, *E. Luehmanniana*, *E. squamosa*, *E. crebra*, *E. paniculata*, *E. siderophloia*, *E. sideroxylon*, *E. amygdalina*, *E. piperita*, *E. hemiphloia*, *E. longifolia* (nursery-seedlings), *E. resinifera*, *E. robusta* (nursery-seedlings), *E. capitellata*, *E. eugenioides*, *E. Sieberiana*, *E. Moorei*, *E. stricta*; and seedlings of several species not identified. We have not been able to get seedlings of *E. botryoides* and *E. maculata*.

Berrima and Moss Vale.—*E. amygdalina*, *E. coriacea*, *E. dives*, and *E. Macarthuri* [all collected by Mr. Cambage; who has also given us two specimens of *E. coriacea* from Jindabyne, N.S.W.]. We are indebted to Mr. E. Cheel for a fine late stage of *E. Sieberiana* from Hill Top.

Marulan.—*E. cinerea* (Argyle Apple), and fine seedlings of three unidentified species locally known as Yellow Box, Broad Peppermint, and Snappy or Brittle Gum [collected by Mr. H. H. Solomon].

Wyalong, N.S.W.—*E. Behriana*, *E. fruticetorum*, *E. viridis* [collected by Mr. W. J. Moffat and Mr. Cambage].

Queensland.—Axillary stem-nodules have been recorded by Mr. Cambage on a seedling of *E. pallidifolia*;* and he has in-

* Journ. Proc. R. Soc. N. S. Wales, xlix., p.435 (1916).

formed us that he has a plant of *E. pruinosa* with stem-nodules, in his bush-house, raised from seed, which he collected in Tropical Queensland.

West Australia.—A pot-plant of *E. macrocarpa* (Pl. x., fig.*b*) which died; we are indebted to Mr. A. G. Hamilton for this specimen. We have seen a flourishing pot-plant of *E. ficifolia*, with two pairs of stem-nodules; but were unable to see how it compares with the two Bloodwoods referred to above, in respect of the presence of an impaired nodule.

New Zealand.—In reply to a request, addressed to a friend in New Zealand, for information about Eucalypt seedlings raised from seed there, we were kindly supplied with five, representing as many species, from the nursery of T. Horton, Ltd., at Hastings or Pahiatua, we are not quite sure which. They are seedlings, from 10-18 inches high, of species that we had not previously seen. Three are labelled *E. Gunnii*, *E. globulus*, and *E. Stuartiana.* The first has two pairs of stem-nodules; the first pair nearly fused, and both have shoots; the stem was broken off just above the second pair. The second, though it is the largest seedling of the lot, has only one pair, unfused. The third has the first pair only, fused on one side. The fourth is wrongly labelled *E. coriacea,* as the leaf-characters are different from those of specimens of this species, from two localities, given to us by Mr. Cambage. This has the first pair very large and warty, not completely fused; one of the second pair very small; and a third pair, very small, and unequal in size. The fifth is labelled "Red-flowering Gum," with an unfamiliar botanical name that we cannot trace in any list of Eucalypts, known to us. This has the first pair large, but not fused, one with two shoots; a second pair, very small, one with a shoot; and the third pair still smaller.

These are the first and only seedlings with stem-nodules from outside Australia that we have seen; or that we know of, except Mr. Clayton Smith's Californian specimens, already mentioned. The interesting thing about them is, that they show substantially what we are accustomed to see in Australian specimens. We have not seen any Tasmanian seedlings, but we shall expect to hear that seedlings of *E. globulus* in Tasmania are liable. We appeal to biologists in other countries, where Eucalypts are acclimatised, to examine seedlings for the presence or absence of axillary stem-nodules; and to record their observations.

The problem, in which we hope our illustrations (certainly an advance upon what has hitherto been attempted, though there is scope for supplementing them), will arouse some interest, is not a simple problem, that can be solved by anyone single-handed. Even when the systematic botanist has done his share, the problem, in its entirety, requires team-work—the active co-operation of the field-botanist, the phytopathologist who is an expert bacteriologist, the morphologist, and the biochemist. The time is ripe for its consideration. The Mallee Scrubs are steadily vanishing in the more accessible districts of several of the States. The investigations of Erwin Smith and some of his colleagues, on Crown-Gall, reported in detail as to technique, the histology of the tumours, &c., and well illustrated,* are available for the bacteriologist as a starting-point. In addition, there are Erwin Smith's "Bacterial Plant-Diseases" (3 vols. already published), besides his numerous papers on the subject of plant-tumours, as well as Clayton Smith's paper; so that there is ample literature to begin with.

In Coville and Macdougall's "Desert Botanical Laboratory of the Carnegie Institution," in Hornaday's "Camp-Fires on Desert and Lava," and in Vols. xiii., and xvi., of Contributions from the U. S. National Museum, a number of characteristic, North American desert plants are described, and in many cases illustrated. Some are said to have thickened, underground trunks, or to be shrubs with numerous stems from a single root, or with several stems clustered at the top of a thick, black root, or with numerous stems given off from a thickened root. Some of them, to us, are suggestive of the appearance and habit of the Australian Mallees. If the seedlings of the most remarkable of them have not been investigated, we would call the attention of American botanists to the advisability of examining these, in order to test the current interpretations of the adult condition;

* "Crown Gall of Plants: its Cause and Remedy," and "The Structure and Development of Crown-Gall: a Plant-Cancer." Bulletin, Nos. 213 (1911) and 255 (1912), Bureau of Plant Industry, U.S. Dept. of Agriculture.

and to ascertain whether any of them are comparable with the Australian Mallees.

We are greatly indebted to our correspondents at a distance, for their kindness and trouble in sending us such material as they were able to get. But we are specially indebted to Mr. Cambage, not only for material, but for his valuable help in identifying a number of our seedlings, and in other ways. We have also to thank Principal Potts for the opportunity of getting samples of seedlings of four species from seed-beds at the Hawkesbury College which have been of great use to us; and to Mr. A. A. Lawson for help in completing our series of photographs.

Corrigendum.—Page 191, line 31—*for* length *read* lengthen.

EXPLANATION OF PLATES IV.-XXVI.

Figs.A1, A2.—Nodules in axils of cotyledons (*E. corymbosa*).

Figs.B1-B3.—Nodules in leaf-axils (*E. hemiphloia*).

Figs.C1, C2.—Nodule-shoots after injury to growing-points of seedling-stems (*E. hemiphloia*).

Plate v.

(Upper row, right-left).—Gradational series of five young seedlings, with from one to three pairs of axillary nodules (*E. hemiphloia*).

(Lower row).—Five similar seedlings of *E. sideroxylon*.

Plate vi.

Fig.1.—Stem-encircling tumour, with shoots (*Angophora lanceolata*); no roots incorporated yet.

Fig.2.—Three pairs of axillary nodules (*E. tereticornis*).

Fig.3.—Second-growth tumour-shoots with axillary nodules (*E. resinifera*).

Plate vii.

Miscellaneous, remarkable seedlings. (Left-right), 1-3, *E. eugenioides*; 4 and 6, *E. piperita*; 6 and 7, *E. hæmastoma*; (nat. size).

Plate viii.

Four anomalous seedlings (a, *E. resinifera*; b1, b2, *E. hemiphloia*; c, *E. sideroxylon*); nat. size.

Plate ix.

Refractory seedlings (*E. robusta*) with from one to six, futile nodules; (nat. size).

Plate x.

Another series of refractory seedlings. (Left-right); a, *E. robusta*; b, *E. macrocarpa*; c1, c2, *E. longifolia*; (nat. size).

Plate xi.

(Left-right), 1-4, *E. corymbosa*; 5-8, *E. eximia*; (*a*, cotyledonary, axillary nodules; *x*, unpaired nodule: *r.n.*, root-nodule); nat. size.

Plate xii.

(Left-right), three root-nodules, *r.n.* (*E, hemiphloia*); 2, two tumour-shoots with axillary nodules (*E. piperita*); three examples of failure, on the part of the nodules, *a'*, to capture the buds, *ax. sh.*, (*E. eugenioides*).

Plates xiii.-xvii.

E. sideroxylon-series, continued from the lower figure of Plate v. (See pp.216-219).

Plate xviii.

E. eugenioides: belated, axillary stem-nodules at nine levels, in addition to the concrescence (*a*); ($\times \frac{2}{3}$).

Plate xix.

E. eugenioides: a belated stem-nodule (A2) and its main shoot, getting their chance on the death of the seedling-stem (*s.st.*).

Plate xx.

E. tereticornis: encircling insect-gall on large tumour-shoot (after the seedling-stem perished); nat. size.

Plate xxi.

Fig.1.—*E. Behriana* (sometimes a tree).

Fig.2.—Non-Mallee (*E. tereticornis*); last stage.

Fig.3.—A Mallee (*E. viridis*).

Plate xxii.

Mallees: 1a, 1b, *E. stricta*; 2, *E. Moorei*; 3, *E. fruticetorum.*

Plate xxiii.

Tumour of *E. Behriana*; ($\times \frac{2}{3}$).

Plate xxiv.

A small "Mallee-Root" from Wyalong, N.S.W. (*E.* sp.).

Plate xxv.

Fig.1.—Seedling of *E. tereticornis*, with nodule-shoots, and precocious branching.

Fig.2.—A Mallee (*E. oleosa* ?); photo taken 50 miles north of Adelaide.

Plate xxvi.

Fig.1.—A nearer view of the basal portion of the Mallee shown in Plate xxv., fig.2; the soil has been scraped away from the base.

Fig.2.—Basal portion of a Mallee (*E.* sp.) at Wyalong; the soil has been scraped away. White background furnished by handkerchiefs.